AC:

TRANSFORMERS

Unclassified

Safety & Environmental Impact is “LOW”

AC: Transformers

Terminal Learning Objective

ACTION:

Answer questions pertaining to basic transformers values and operation.

CONDITIONS:

Without Reference.

STANDARD:

A minimum of 7 out of 10 questions answered correctly .

AC: Transformers

Introduction

AC would have never reached its high level of use if it were not for the transformer.

Transformers make it possible to change AC voltage and current values. They provide a way for efficiently transferring electrical current long distances.

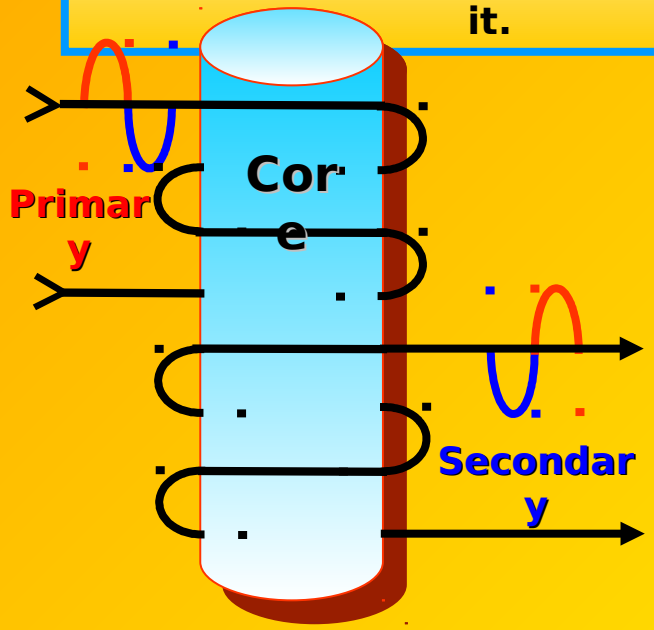
During this lesson you are going to study the transformer in detail.

AC: Transformers

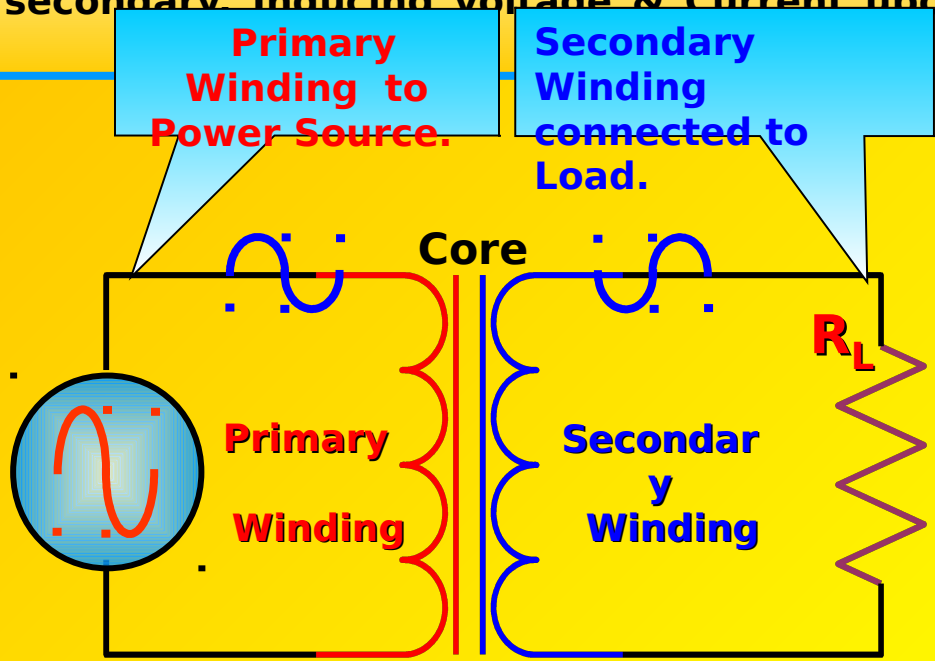
Concept; A transformer changes the AC input line Voltage and Current of one value on the input to a different value on the output.

Mutual Inductance;

The process of transferring the energy from the primary to the secondary coil is due to the expansion & contraction of the magnetic field on the primary, cutting across the secondary. Inducing voltage & Current upon it.



Construction



Schematic

Core

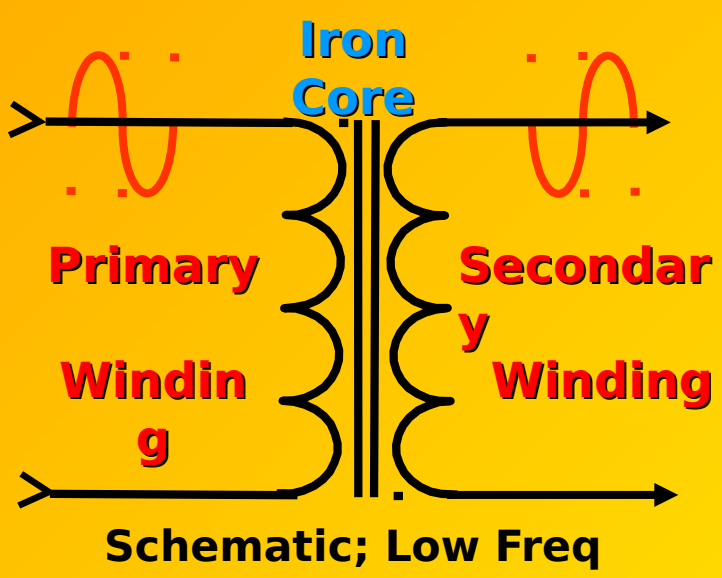
AC: Transformers

Core Types;

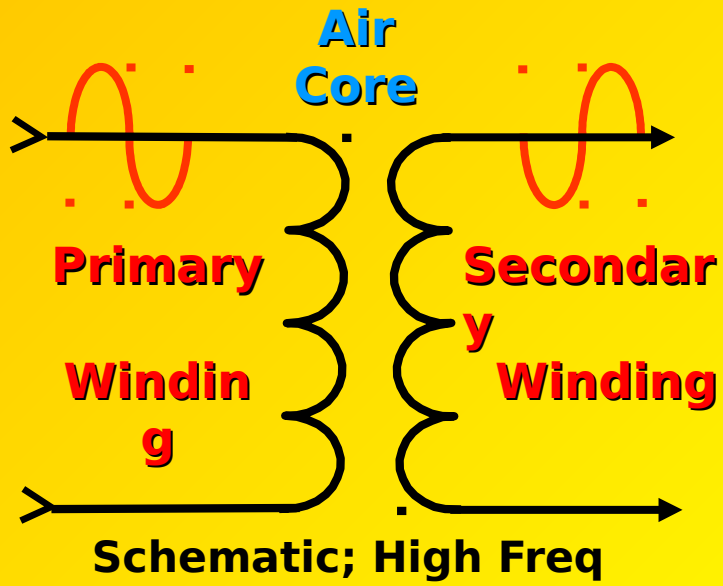
Transformers will have either an Air Core or Iron Core, dependent upon the application.

Iron core: Used with audio frequencies [AF] between 20 Hz - 20 KHz.

Air core: Used with radio frequencies [RF] 20 KHz and above.



Schematic; Low Freq



Schematic; High Freq

Phase

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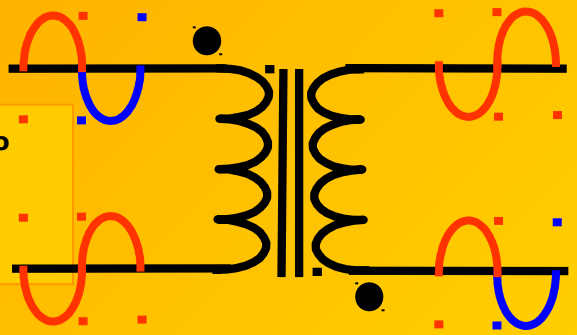
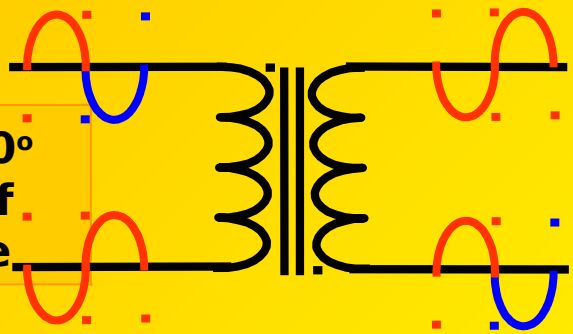
Phase Shift;

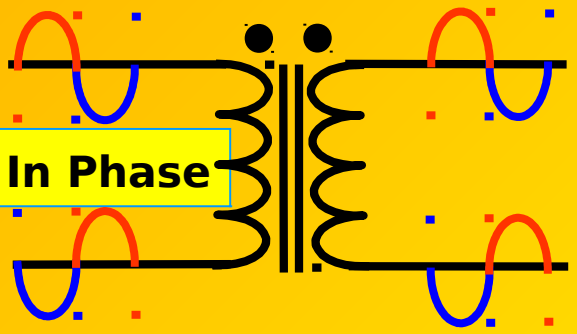
The expansion & contraction of the magnetic fields around the primary onto the secondary coil is such that current is induced in the secondary coil. Current flows in the opposite direction than the primary, A 180° phase shift is the evident result.

A. 180° Out of Phase



B. 180° Out of Phase





C. In Phase

In Phase;

A core can also be wound so that the Primary & Secondary are in Phase, these are less common & incur additional expense.

Ratio

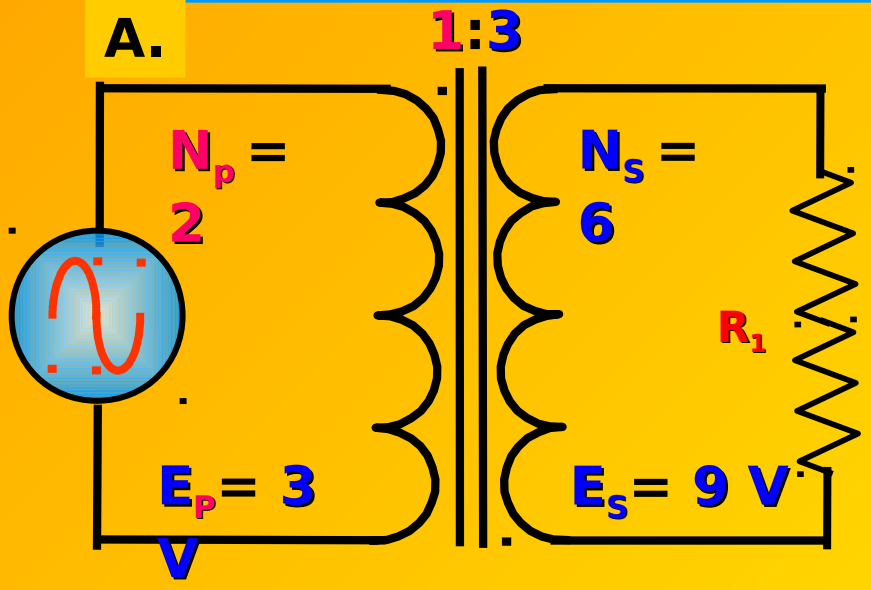
AC: Transformers

Turns Ratio;

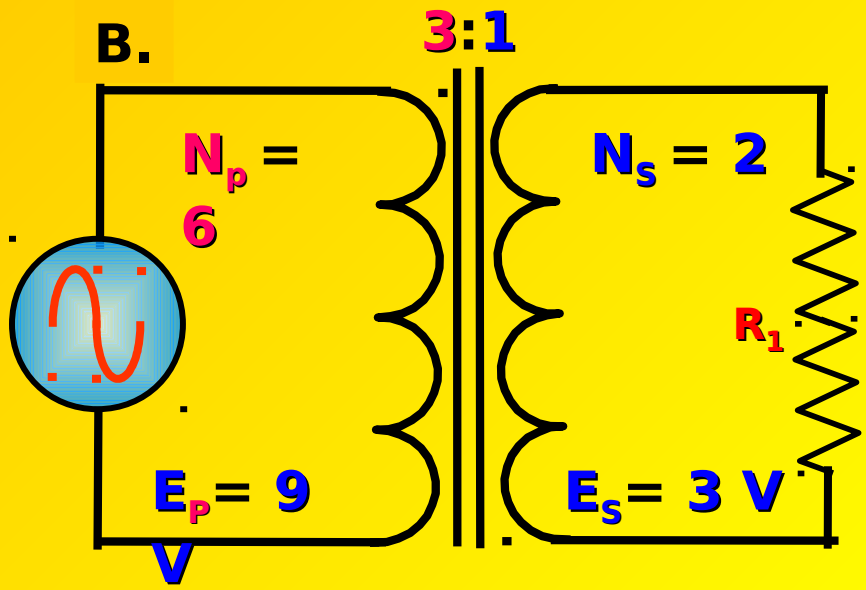
N_p = # of turns in primary. E_P = Voltage on Primary

N_S = # of turns in Secondary. E_S = Voltage on Secondary

A.



B.



?

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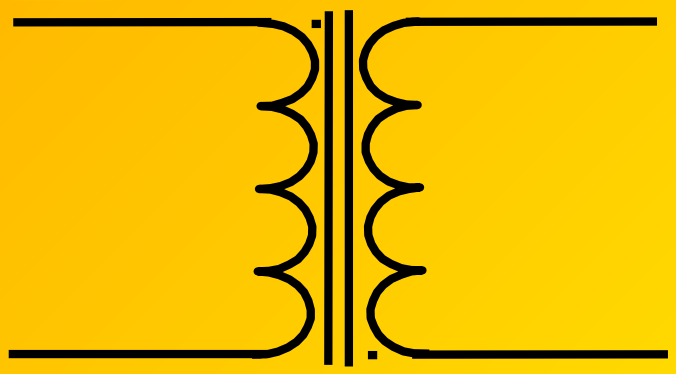
Turns Ratio;

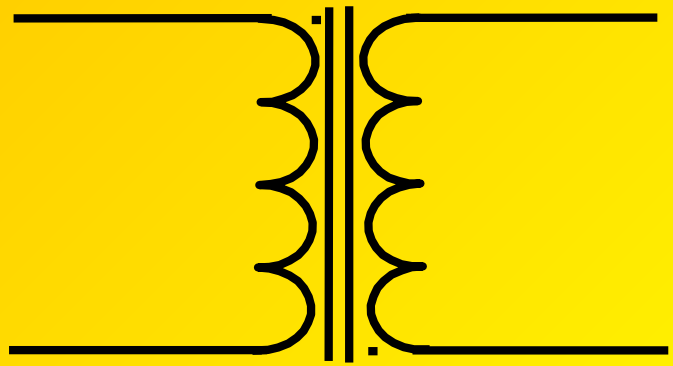
Is always reduced & expressed in the lowest terms with one of the numbers being “1”.
The Largest number represents how many times greater the Voltage is than the smaller Number.

What is the turns ratio?

A. **5:15**



B. **25:5**



Multiple Sec

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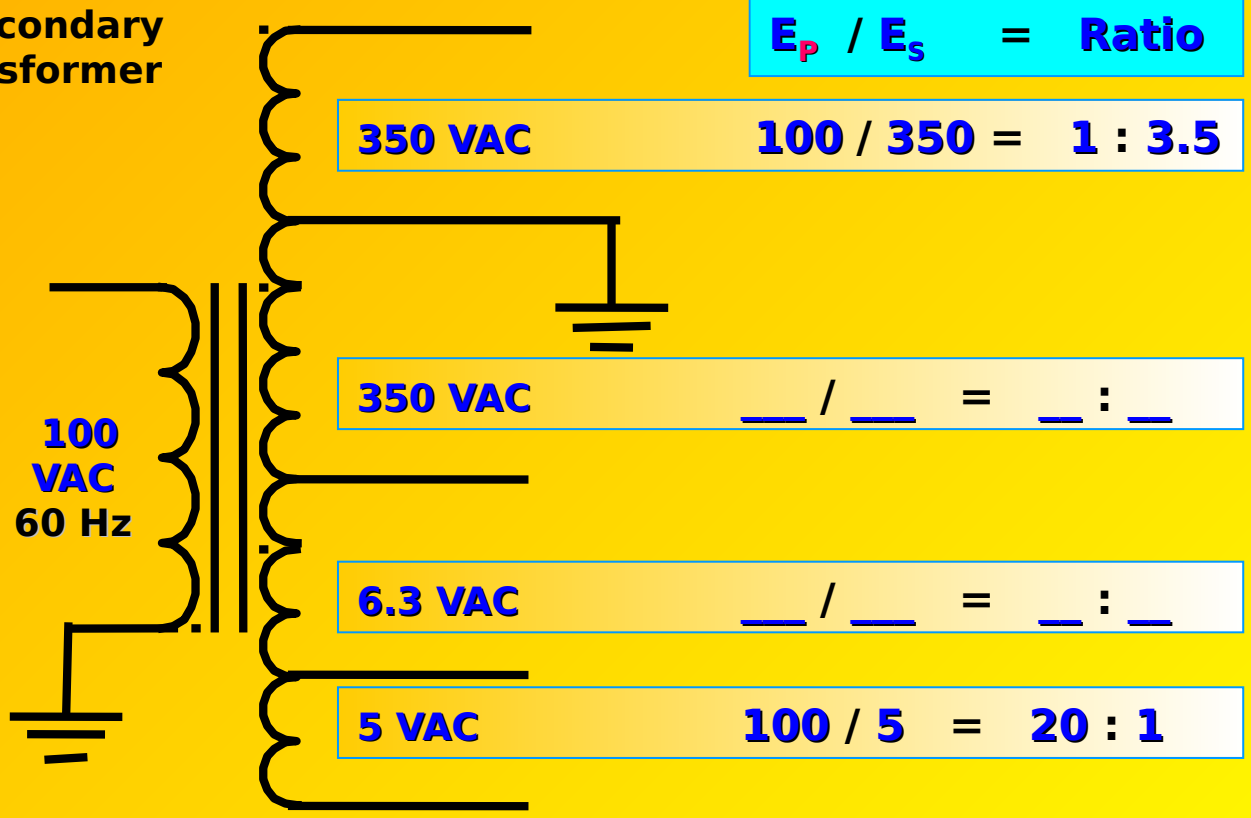
Multiple Transformer windings;

Provides several different output voltages on the Secondary. Reducing the voltages determine the Ratio, from Primary to Secondary.

Multiple Secondary Power Transformer



Calculations

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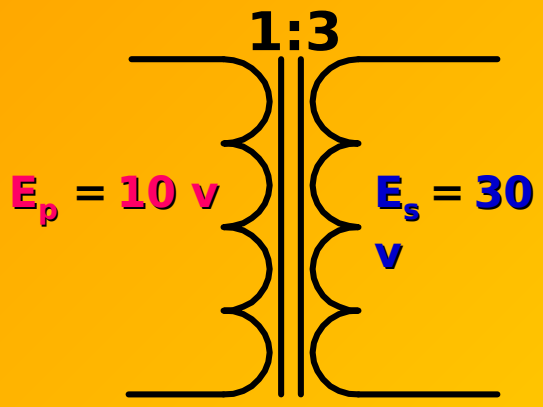
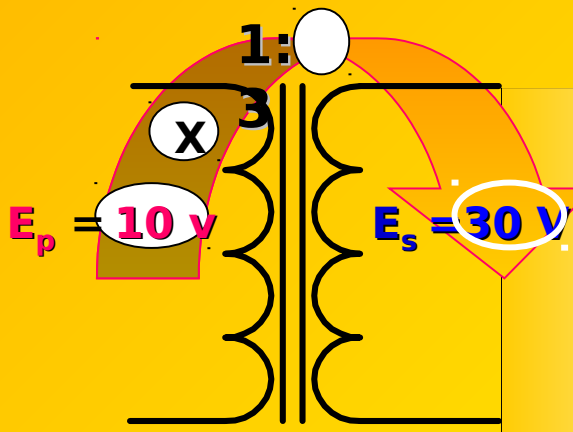
Step Up & Step Down; Refers to Voltage "ONLY".



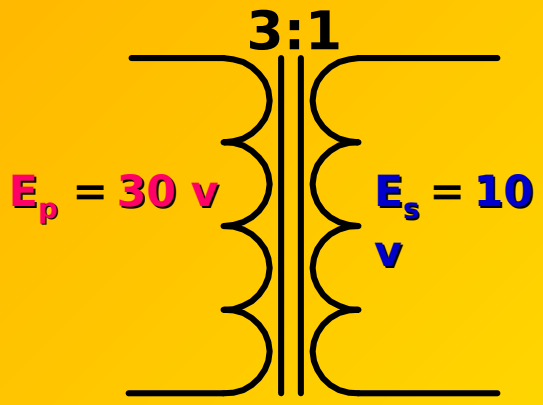
Step-Up Transformer



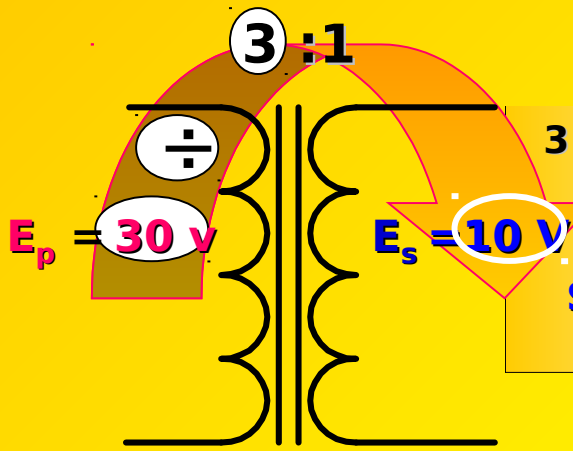
3 Indicates the Secondary is High .

Primary is low

Step-Up Transformer



Step-Down Transformer



3 Indicates the Primary is High .

Secondary is low .

Step-Down Transformer

Current

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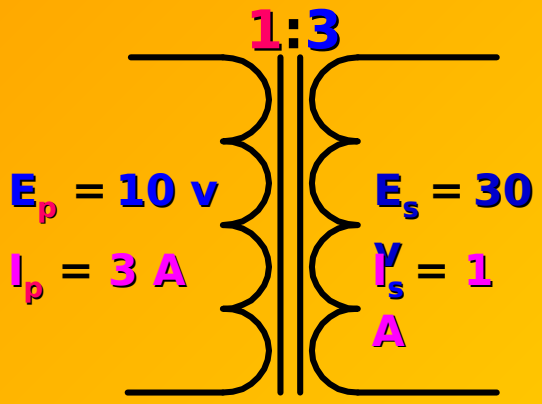
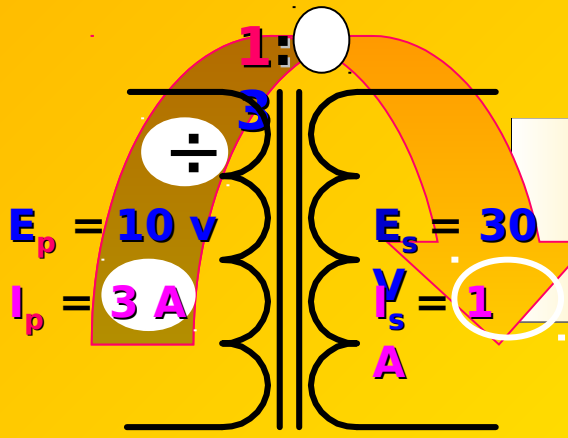
Step Up & Step Down; Refers to Voltage, Current is the opposite of voltage.



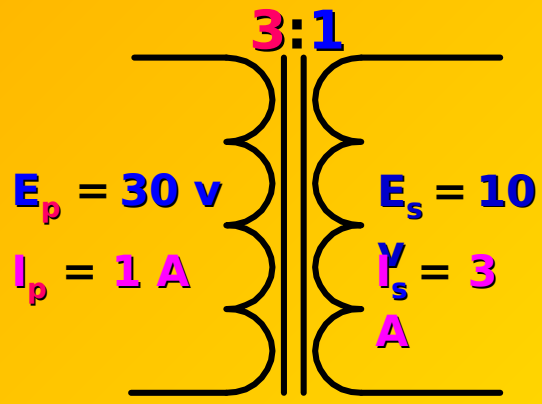
Step-Up Transformer



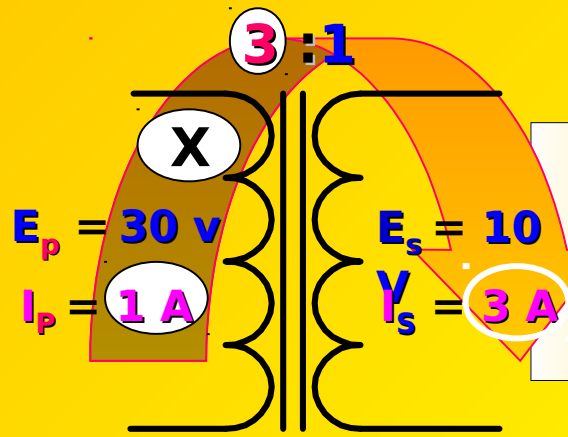
Secondary Voltage is High

Current is Low .

Step-Up Transformer



Step-Down Transformer



Secondary Voltage is low .

Current is HIGH

Step-Down Transformer

Power

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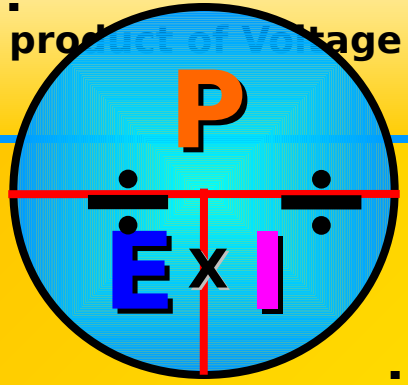
Power;

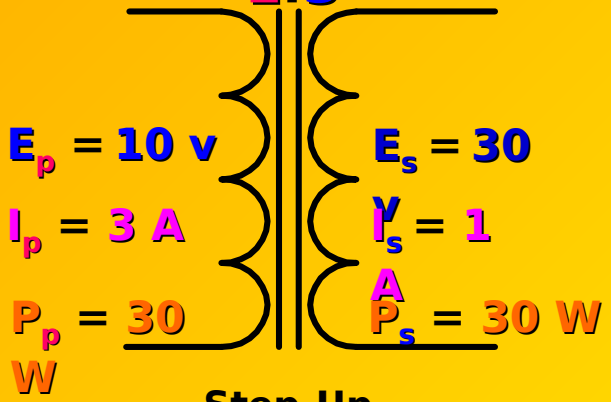
Power in, is equal to, Power out.

Transformers will be considered 100% efficient. E_P X I_P = E_S X I_S

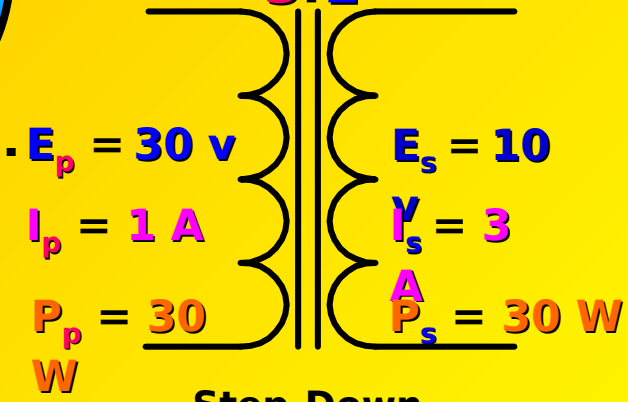
When Voltage (E) is stepped up, then Current (I) is stepped down.

Power is a product of Voltage & Current, E X I = P





Step-Up Transformer



Step-Down Transformer

Challenge

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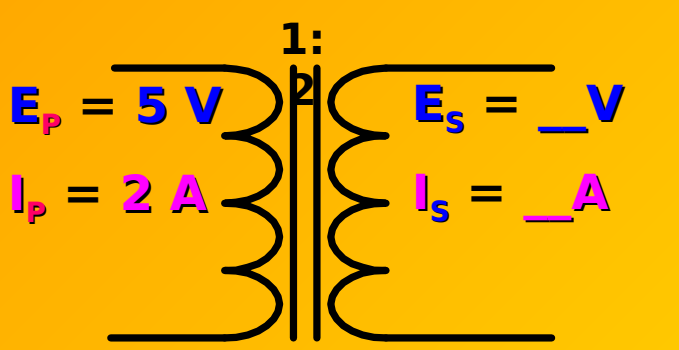
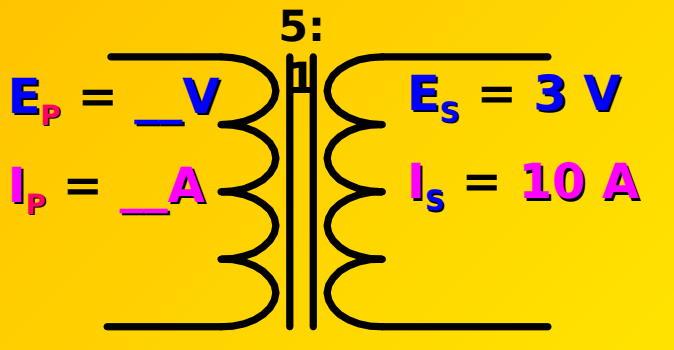
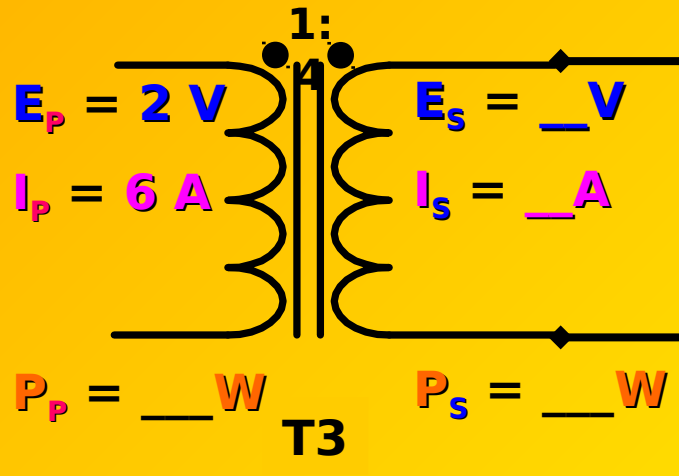
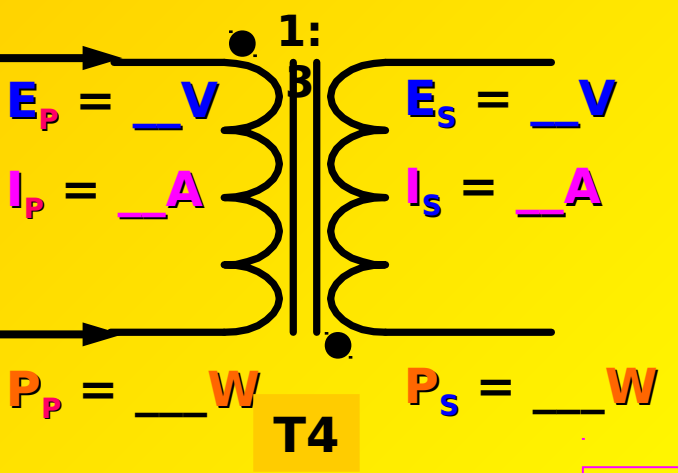
Calculate Voltage, Current & power.





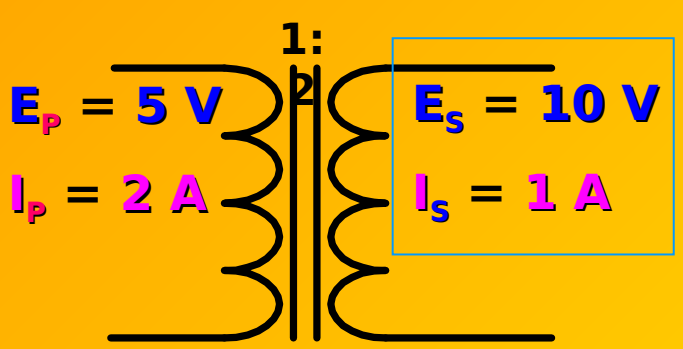




Answers

AC: Transformers

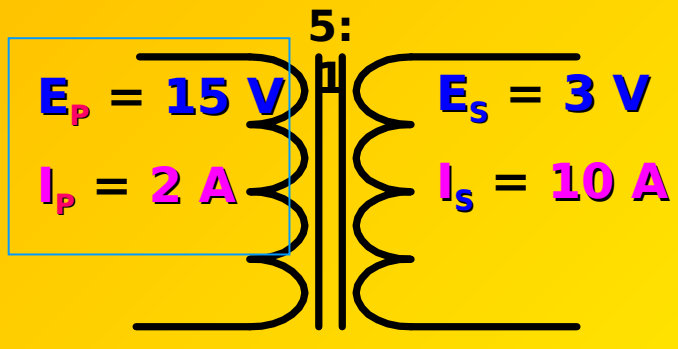
Calculate Voltage, Current & power.



P_P = 10 W

T1

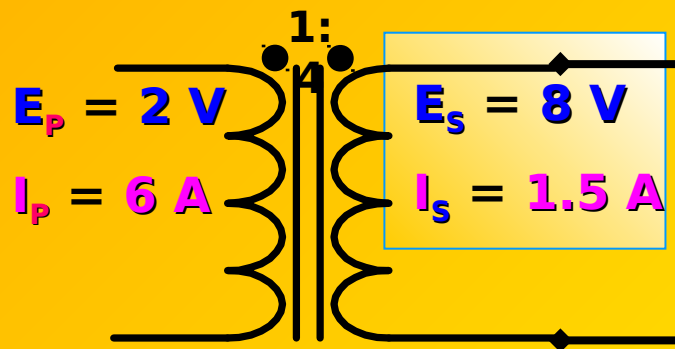
P_S = 10 W



P_P = 30 W

T2

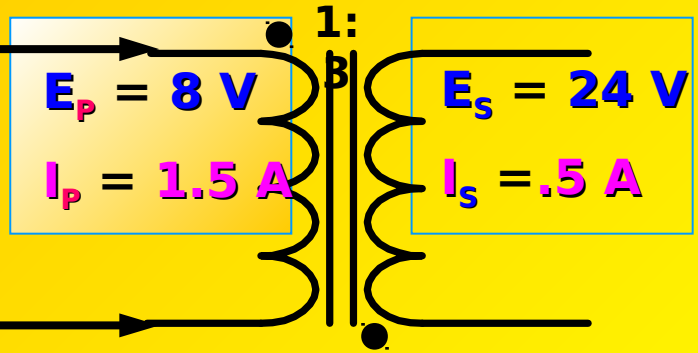
P_S = 30 W



P_P = 12 W

T3

P_S = 12 W



P_P = 12 W

T4

P_S = 12 W

Types; Auto

AC: Transformers

Autotransformers;

Have only one winding & a common wire for the primary and secondary.

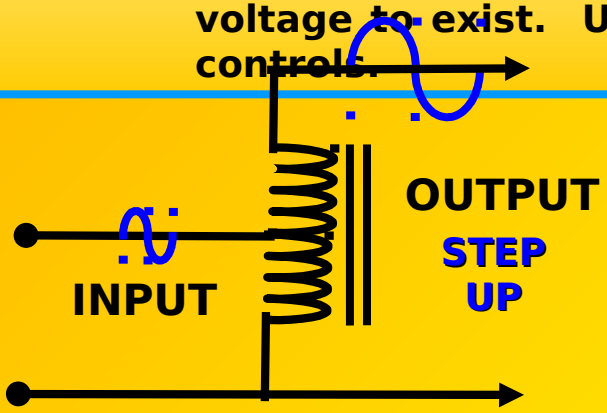
Both the primary & secondary currents flow through the same wire.

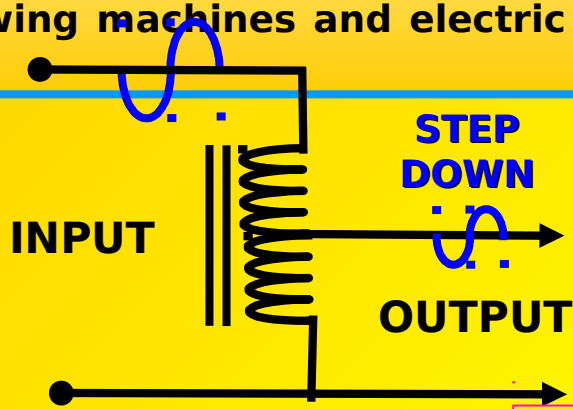
<u>Cheaper</u>, because of the single winding and smaller core.

Disadvantage; <u>No isolation</u> between the circuit and the line, a shock hazard exist.

Autotransformer;

Term originates from the <u>automatic voltage regulation</u> that it provides. Despite changes in load current, the opposing current strikes a balance which causes a stable output voltage to exist. Used in sewing machines and electric train controls.





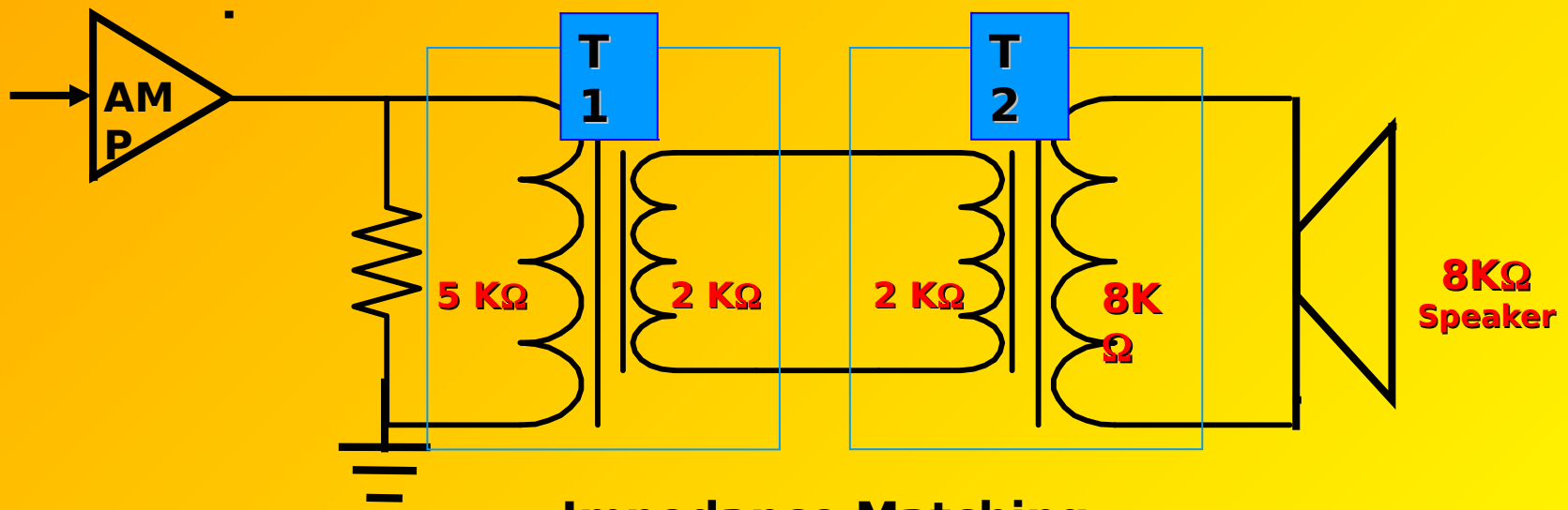
Impedance Matching

AC: Transformers

Impedance matching;

For maximum power output.

Transformers are often used to match impedance between two circuits due to the number of turns on the primary and secondary windings can be controlled in manufacturing.



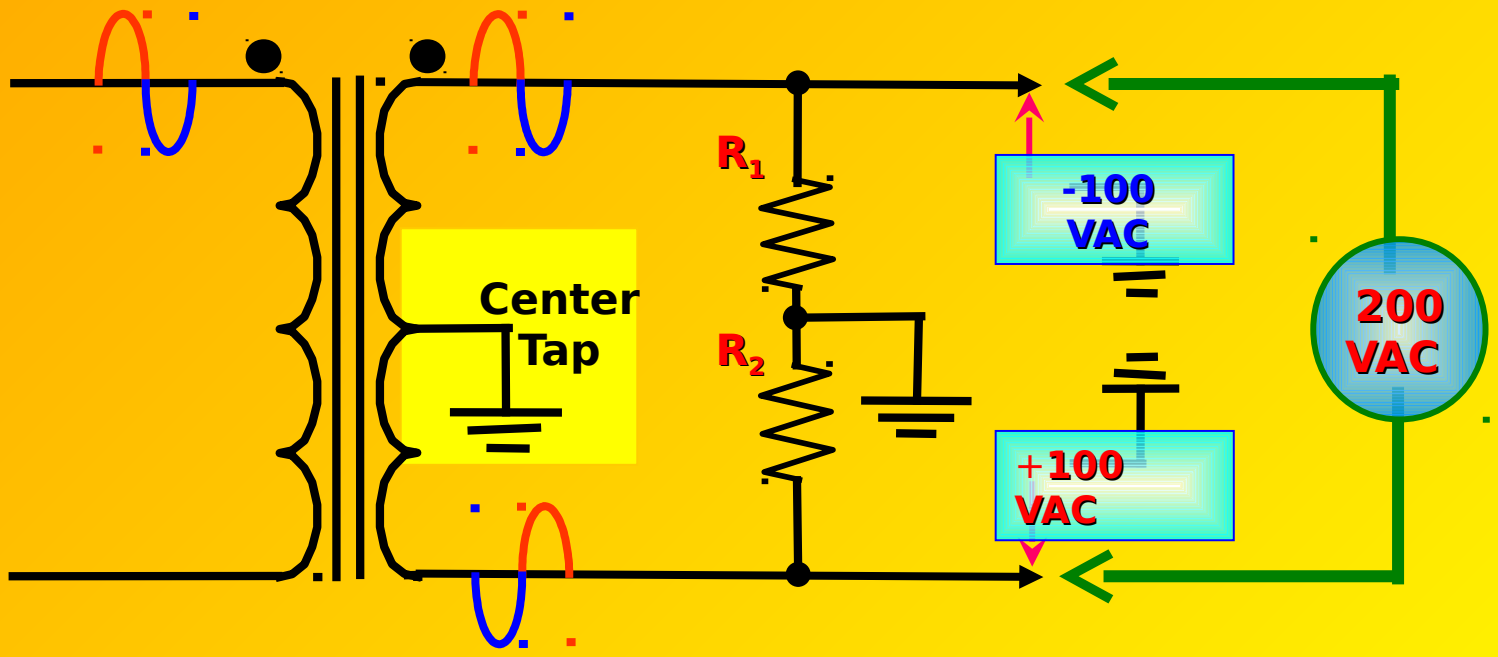
Impedance Matching

Center Tap

AC: Transformers

Center Tap;

Placing a ground on the secondary winding, creates two Voltages of the same value, but opposite in polarity. This ground is referred to as a “Center-Tap”.



Job1:

AC: Transformers

JOB: 1 Transformer Operating Principles.

a. What is the definition of a transformer?

_____

b. Name the winding which has power applied to it?

_____

c. Name the winding which has the load connected to it?

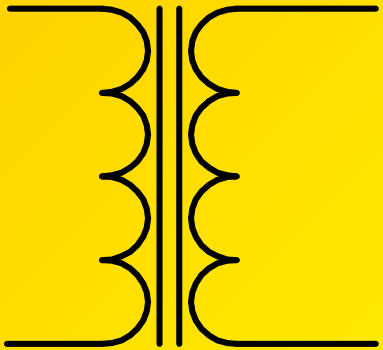
_____

d. What are the three major parts of this transformer?

_____

_____

_____



Answers; a - d

AC: Transformers

JOB: 1 Transformer Operating Principles; Continued.

e. **What type of core is used to increase transformer efficiency at low frequencies?**

_____

f. **What is the principle of operation for a transformer?**

_____

g. **Will a transformer transfer AC power from the primary to the secondary?**

_____

h. **Will a transformer transfer DC power from the primary to the secondary?**

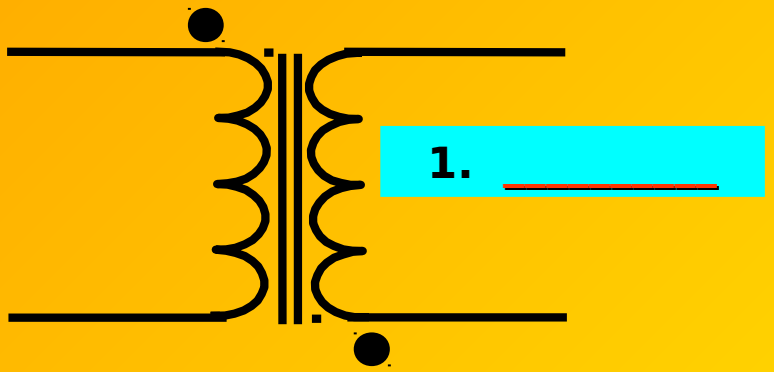
_____ **Why?** _____

Continued

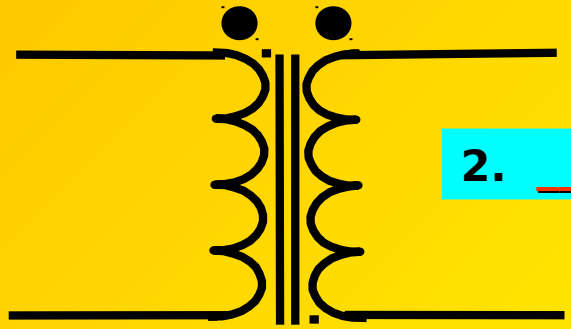
AC: Transformers

JOB: 1 Transformer Operating Principles; Continued.

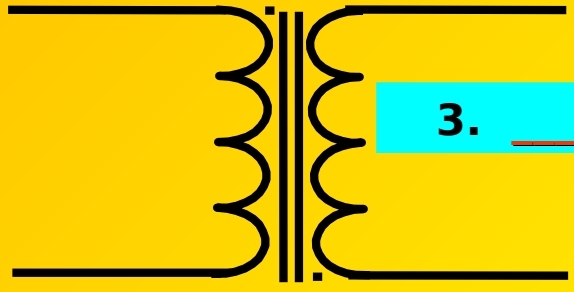
i. What is the phase relationship between primary and secondary voltages for the following transformers?



1. _____



2. _____



3. _____

Answers

AC: Transformers

JOB: 2 **Solve for turns ratio, primary and secondary Voltages, Current & Power.**

a.

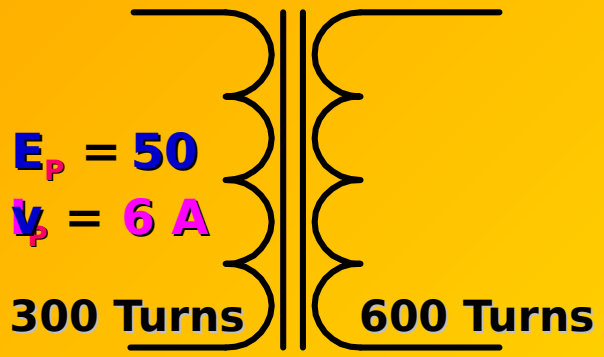


Figure 1

1. **Phase relationship =** _____
2. **Type of Core =** _____
3. **Turns Ratio =** _____
4. **Step Up/Down =** _____
5. **Secondary Voltage =** _____
6. **Secondary Current =** _____
7. **Primary Power =** _____
8. **Secondary Power =** _____

Answers

AC: Transformers

JOB: 2 **Solve for turns ratio, primary and secondary Voltages, Current & Power;** Continued.

b.

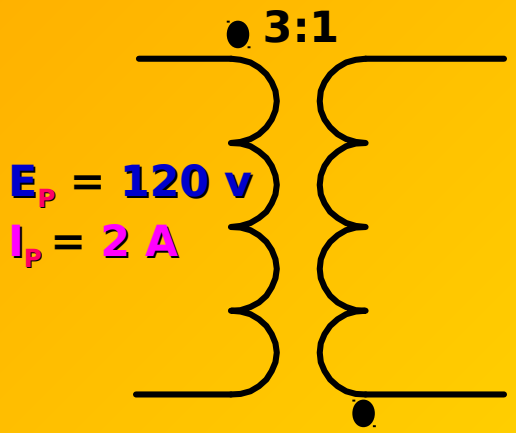


Figure 2

1. **Phase relationship =** _____
2. **Type of Core =** _____
3. **Step Up/Down =** _____
4. **Secondary Voltage =** _____
5. **Secondary Current =** _____
6. **Primary Power =** _____
7. **Secondary Power =** _____

Answers

AC: Transformers

JOB: 2 **Solve for turns ratio, primary and secondary Voltages, Current & Power;** Continued.

c.

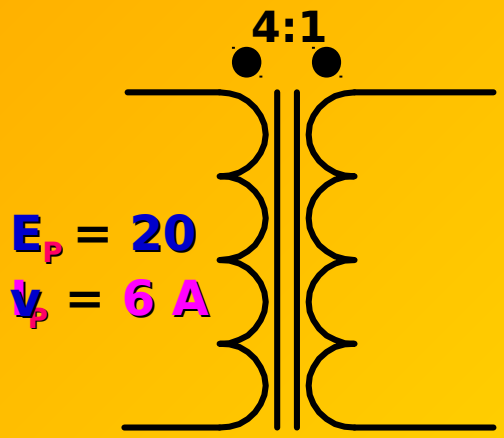


Figure 3

1. **Phase relationship =** _____
2. **Type of Core =** _____
3. **Step Up/Down =** _____
4. **Secondary Voltage =** _____
5. **Secondary Current =** _____
6. **Primary Power =** _____
7. **Secondary Power =** _____

Answers

AC: Transformers

JOB: 2 **Solve for turns ratio, primary and secondary Voltages, Current & Power;** Continued.

d.

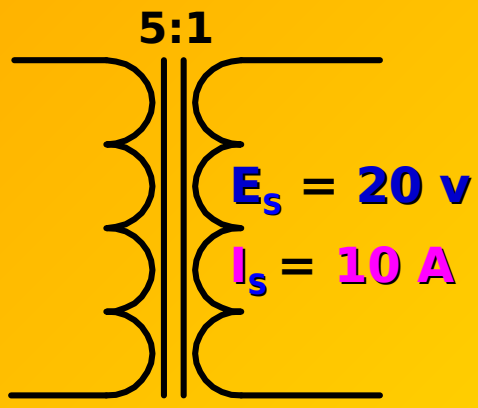


Figure 4

1. **Phase relationship =** _____
2. **Type of Core =** _____
3. **Step Up/Down =** _____
4. **Primary Voltage =** _____
5. **Primary Current =** _____
6. **Primary Power =** _____
7. **Secondary Power =** _____

Answer

AC: Transformers

JOB: 2 **Solve for turns ratio, primary and secondary Voltages, Current & Power;** Continued.

e.

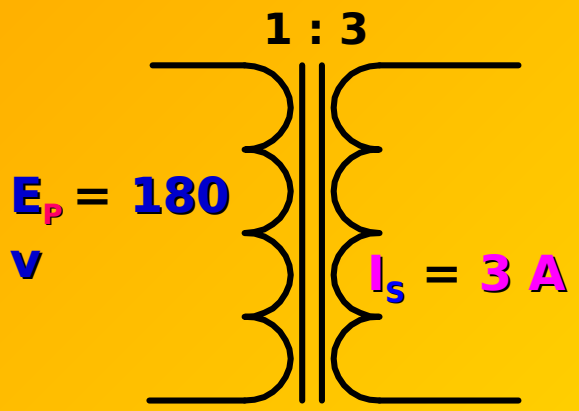


Figure 5

1. **Phase relationship =** _____
2. **Type of Core =** _____
3. **Step Up/Down =** _____
4. **Secondary Voltage =** _____
5. **Primary Current =** _____
6. **Primary Power =** _____
7. **Secondary Power =** _____

Answers

AC: Transformers

JOB: 2 **Solve for turns ratio, primary and secondary Voltages, Current & Power;** Continued.

f.

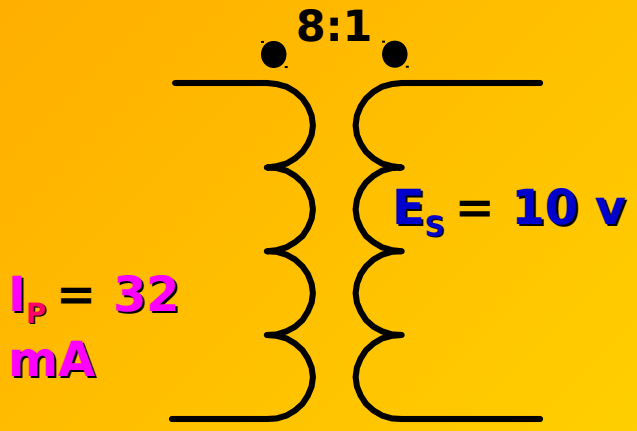


Figure 6

1. **Phase relationship =** _____
2. **Type of Core =** _____
3. **Step Up/Down =** _____
4. **Primary Voltage =** _____
5. **Secondary Current =** _____
6. **Primary Power =** _____
7. **Secondary Power =** _____

Answers

AC: Transformers

SUMMARY :

Self induction;

Is the opposing flux lines cutting across the coils producing counter electromotive force, such as in the Autotransformer.

Mutual Induction;

In one coil induces a voltage in another coil by its flux lines cutting across the windings of the second coil.

Primary Winding;

The coil generating the flux lines.

Secondary Winding;

The coil in which the flux lines are inducing a voltage.

Iron core;

Frequencies 20KHz and below, [Power Transformers].

Air core;

20KHz and above.

Phase;

Transformer can be 180 degrees out of phase or in phase by reversing the winding process on the secondary.

Power;

In the primary is always equal to the power in the secondary.

Test

AC: Transformers

QUESTIONS:

LESSON TEST:

Time; **20 Minutes.**

References; **Official OMEMS Training Aids.**

Standard; **7 of 10 questions must be correct.**